

Improvements in Manufacturing the PVI Powergrid™

Highlights

- Reduced cost of manufacturing modules by 41%
- Increased production capacity of linear concentrators by factor of 5
- Developed in-house capability to extrude Fresnel lenses, lowering product materials cost by 37%
- Increased lens manufacturing capability to 5 MW/yr
- Completed first half of automated receiver-assembly station development

Photovoltaics International, LLC, is part of the 1995 solicitation of PVMaT—a cost-shared partnership between the U.S. Department of Energy and the nation's PV industry to improve the worldwide competitiveness of U.S. commercial PV manufacturing.

Photovoltaics International, LLC

Goal

Photovoltaics International's (PVI) goal under the 1995 PVMaT solicitation was to reduce the production cost and increase production volume of the company's linear focus concentrator. PVI's objectives were to:

- reduce linear concentrator module-manufacturing costs to \$2.00/watt
- increase module performance
- provide the groundwork for expanding PVI production capacity to 50 MW/yr
- reduce the use of volatile organic compounds (VOC) and hazardous materials in manufacturing.

This PVMaT project should reduce the cost of the Powergrid by about \$3 per watt at a mature production volume.

Background

The PVI Powergrid is a linear-focus concentrator that uses low-cost components and manufacturing techniques to reduce the price of a PV system to its absolute minimum. A plastic extrusion process is used to make the linear-focus acrylic Fresnel lens and module sides. The Powergrid lenses focus sunlight on a 10X concentration ratio, with the system using one-sun solar cells. Twelve modules, producing a total of 1 kW of power, are mounted on a stationary panel frame that moves them in unison for single-axis tracking. The panel powers the tracking motor so that no batteries or grid connection are required for tracking.

PVI developed the Powergrid under a Concentrator Initiative program with Sandia National Laboratories. With Sandia and the California Energy Commission, the company installed pilot production equipment and was able to demonstrate a production rate of 830 kW per year.

Technical Approach

PVI's approach to reduce manufacturing costs for the Powergrid relies on identifying elements that contribute most to manufacturing cost and on selecting leveraging manufacturing techniques. The company has identified the areas with the greatest potential for reducing costs as lens and side extrusion, cell lead attachment, panel frame assembly, and module assembly.



Once installed, this PVI concentrator has virtually no operating and maintenance costs; no fuel costs, harmful emissions, or pollution.

Results

Installed Advanced Acrylic Plastic Extrusion System for Lenses and Module Sides

PVI has installed a previously designed advanced system to extrude acrylic plastic. The integrated system includes a raw material handling and drying section, the extruder, a flying cut-off saw, and a parts unloader. The machine has much greater control of the extrusion parameters than earlier designs.

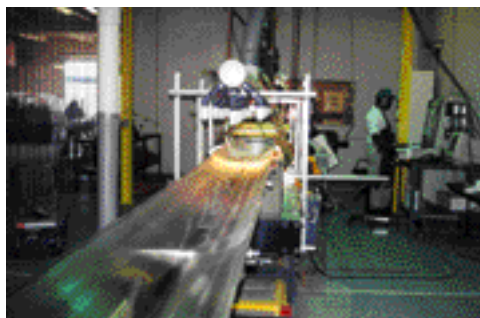
In a 50-unit production run, lenses had greater than 80% optical throughput, compared to 68% for lenses made by a contract vendor. This improvement is directly attributable to greater control. Results also showed two key areas of

process improvement that may improve process yield: more uniform temperature control of the die and more control over flow of air cooling at the die exit.

In experiments with extruding lenses, PVI made lenses with 85% optical transmission. Improvements were due to enhanced control of die temperatures and better display of operating parameters in real-time graphical displays on the computer monitor. In subsequent production runs, more than 99% of the lenses produced had high optical transmission and were usable for product—compared to less than 50% previously.

The extrusion system has been demonstrated to operate at a production rate of 4 MW per year and with yields exceeding 95% for lenses, with optical throughput of greater than 82%. PVI plans to increase the rate by a factor of three, with an average optical throughput of the lenses of greater than 87%. The lens optical throughput was boosted by improving the die finish and by post-roll-forming experiments to improve the accuracy and fidelity of the finished Fresnel lens.

The acrylic plastic sides of the module have well-controlled features and are also extruded by using a different die. Production trials demonstrated a production rate of the extruder equivalent to 2 MW per year, with yield greater than 90%.



William Bottenberg/PIX08948

A half-panel PVI model is being adjusted in a testing wind tunnel.

Assembled Cell Lead Attachment Section of Automatic Receiver Assembly Station

For the automated receiver assembly station, PVI thoroughly tested and debugged each sub-assembly of the cell lead-attachment section before performing system integration. The system uses a robot to transfer cells from a stack to a lead-attachment nest. The nest holds the cell in place while the leads and insulators are positioned prior to the solder-bonding process. An infrared

heater station does the actual soldering. PVI performed trial runs of the lead-attachment process after the robot-control and other station-control software was integrated. Fifty-two cells were processed at a rate of 1 cell per 2 minutes, and the net yield was 96% for cells that met all leaded cell qualification criteria.

Designed and Prototyped Low-cost, Roll-form Steel Panel Frame Assembly

PVI fabricated panel frames using aluminum extrusions to simulate roll-form members. Two of these frames are deployed on PVI's own roof. The original concept was to use a dedicated lock-seamed, roll-formed structure, but the costs are relatively high. Numerous tube-section options are available, though, if the requirement for a lock-seam configuration is relaxed. Using off-the-shelf material substantially reduces tooling costs.

A 12-module group was fabricated that has an average output of 139 watts (± 7 watts) at PVUSA test conditions (850 W/m² irradiance, 20°C ambient temperature, and 1 m/s wind speed). These modules are mounted for outdoor testing on PVI's roof.

Company Profile

Photovoltaics International LLC (PVI) is a manufacturer of photovoltaic systems that produce clean, low-cost power with minimal impact on the environment. PVI is a full service company that provides equipment, system design, installation and field services for a wide range of energy needs.

PVI was created in 1995 as a jointly owned company with its two corporate shareholders: a majority shareholder, American Consumer Industries Inc. (ACI) and a minority shareholder, Solar Engineering Applications (SEA), founded in 1988.

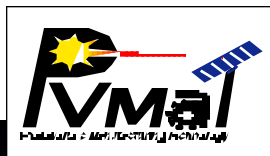
Subsequent to its formation in 1988, SEA Corporation developed a concentrating PV system with support from the U.S. Department of Energy and the California Energy Commission.

PVI's 18,000-sq. ft. manufacturing facility, located in the heart of Silicon Valley (Sunnyvale, California) is capable of producing 10 MW/yr. of systems.

References

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